The effect of dead wood and understory coverage on small rodent abundance in Korean forest

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Abstract: This study was conducted to investigate the population characteristics of small rodents in different habitats with the artificial presence and absence of dead wood, and understory vegetation after forest cutting at natural deciduous forest in north-eastern South Korea from April to December in 1997 and 1998. Two forests, one hectare each (100 × 100 m), were selected and designated as the control and the treatment area. Forest structure of mid and high canopy layers in both study areas was similar. But number and volume of fallen trees, and coverage of understory vegetation were higher in the control area than in the treatment area. Total captures of small rodents in two areas combined comprised *Eothenomys regulus* (55.5%, n = 211) and *Apodemus peninsulae* (44.5%, n = 169). Total abundance of *E. regulus* and *A. peninsulae*, and population stability were significantly greater in the control area than in the treatment area. The difference in the captured number of two small rodents between the two sites was caused by the difference in reproduction and residency. The structure of forest floor appears to be important to small rodents. The presence of dead wood and understory vegetation after the forest cutting would be necessary for the maintenance of small rodent population in the forest cutting areas.

Keywords: *Apodemus peninsulae*; *Eothenomys regulus*; Understory vegetation; Dead wood
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Introduction

Many researches have recognized the theoretically importance of habitat heterogeneity in population processes (Bondrup-Nielsen 1987). It was shown by many authors that the density and distribution of small rodents among forest habitats depend on the thickness and type of distribution of such elements of the habitat like debris, slash and tall ferns or understory (Evans 1942; Brown 1956; Hansson 1978; Jensen 1982; Wiger 1982; Geuse 1985; Mazrukiewicz, 1991). Different structure elements of forest habitats play an important role in the constitution of favorable life conditions for the small rodents (Mazrukiewicz 1994).

Forest cutting seems to give profound effects on forest dwellers providing with environmental (both physically and biologically) changes (Rhim and Lee 1999). Forest dwelling small rodents must have limits of physiological tolerance and fundamental niche with sufficient breadth to encompass the altered conditions by forest cutting. To serve as habitat for a particular species, a site must fulfill the species' requirement for food, moisture, cover and other specific requirement (Kirland, Jr. 1990).

Apodemus and *Eothenomys* species are the most dominant small rodents in forest areas of South Korea (Won 1967; Yoon 1992). Although, in relatively large scale, we know where those species would distribute, there are a few studies on the habitat preferences and population dynamics of those species, which were based on quantitative analyses of habitats. This type of information should be fundamental for considering their conservation and management, furthermore the understanding of forest ecosystem (Rhim and Lee 2001).

This paper presents an investigation of seasonal fluctuation of Korean large-toothed red-backed vole (*Eothenomys regulus*) and Korean field mouse (*Apodemus peninsulae*) population and its causes in different habitats with high and low amounts of dead wood i.e. fallen trees and dead branches, and understory coverage. The forest floor condition affected spatial and temporal continuity of habitat that could be important to the survival and migration of animals (Maser *et al.* 1979; Lee 1995; Rhim and Lee 1999). It has been hypothesized that habitat structure is an important for inhabitation of small rodents.

This study was conducted to investigate the population characteristics of small rodents in different habitats with the artificial presence and absence of dead wood, and understory vegetation after forest cutting at natural deciduous forest in northeastern South Korea.

Materials and methods

Study area

This study was conducted at the natural deciduous forest of National Forest (37° 27' N, 128° 29' E; 1,060~1,130 m from sea level) in Pyongchang, Gangwon-do Province, north-eastern South Korea from April to December in 1997 and 1998. The study area consisted mainly of natural deciduous trees such as *Quercus mongolica*, *Tilia amurensis*,

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Betula costata, Ulmus davidiana and *Maackia amurensis*. And dominant understory vegetation was *Sasa borealis, Tripterygium regelii, Schizandra chinensis and Pteridum aquilinum* (Rhim and Lee 2001).

Two forests, one hectare each (100 m × 100 m), were selected and designated as the control and the treatment area. The forest practices were done in 1992 according to the plan of national forest management of Korea Forest Service. After the forest practices, there were remained fallen trees and dead branches caused by forest cutting, and understory vegetation in the control area, but all fallen trees, dead branches and understory vegetation were removed from the treatment area.

Each study area was divided into a grid pattern, consisting of a 10 m × 10 m array in 1 hm^2 (100m x 100 m) area. We measured three indices for Habitat structure, such as amount of fallen trees and dead branches, and coverage of understory vegetation (< 1.5 m in height). In each grid (10 × 10 m), a 5-m diameter circle was randomly selected, and habitat structure was surveyed within the circles. Percentage of understory coverage was measured in the 100 sampling circles. The understory coverage was classified into the following four categories based on percentage of understory coverage according to Lee (1996): 0 (coverage percent: 0%), 1 (1%-33%), 2 (34%-66%) and 3 (67%-100%). Number, length and diameter of fallen trees were also measured in each circle.

The measure of diversity was applied to the vegetation data. Tree species diversity (H') value was calculated by the following equation (Shannon and Weaver 1949):

$$H' = \sum_{i=1}^{S} (-P_i) \times \ln(P_i)$$

Where, s is the number of tree species and P_i is the proportion of the number of trees in the i-th tree species to total number of trees.

Trapping

Live trapping, employing capture-mark-release techniques, was conducted monthly on 1 ha grids in each of the two areas during the snow-free seasons (from April to December) of 1997 and 1998. Each grid consisted of 100 trap stations (10 × 10 array with 10 m intervals). A Sherman-type live trap (7.5 cm× 9.2cm × 29.2 cm) with rolled rice was placed at each station. The traps were set in the afternoon and were checked in the following morning (from 09:00). Captured rodents were toe-clipped for individual identification. Each captured animal was weighed to the nearest 0.5g using a spring balance. Identification number, sex, reproductive condition and location were recorded for each capture. Then, they were released at the capture point. 'Three-night' trapping was adopted on the small rodent populations.

Results

The tree density, number of tree species, tree species diversity index (H') and total basal area were similar in both study area (Table 1). This means that forest structure of mid and high canopy layers in both study areas was similar. But understory habitat condition was different between the control and the treatment areas. Number and volume of fallen trees were higher in the control area than in the treatment area. And there were significant differences in coverage of uderstory vegetation ($t = -5.73$, $p = 0.03$) between the control and the treatment areas.

Table 1. The habitat structure of study sites

	Control area	Treatment area
Tree density (no. of trees per ha)	120	128
Number of tree species	16	17
Tree species diversity (H') [1]	1.98	1.92
Total basal area (m^2/hm^2)	4.59	4.46
Number of fallen trees	82	7
Volume of fallen trees (m^3)	13.52	1.46
Volume of dead branches (m^3)	25.17	7.98
Coverage of understory vegetation*	2.13	1.24

*- denotes significant differences between the control and the treatment areas ($p<0.05$, t-test)

Total captures of small rodents in two areas combined comprised *Eothenomys regulus* (55.5%, n=211) and *Apodemus peninsulae* (44.5%, n=169). The both of small rodent species were captured in the both study areas. Total abundance of *E. regulus* and *A. peninsulae* was significantly higher in the control area. The minimum number alive (MNA) of *E. regulus* gradually increased and reached the peak in October at the two study areas. Similarly, MNA of *A. peninsulae* reached peak in September and October at the two study areas. The small rodents population showed typical seasonal cycles with greatest number in fall when young were produced, followed by a decline into winter (Rhim 1997) (Fig. 1 and 2).

The mean difference analysis of Hotelling-Lawley's T^2 test shows significant differences ($p < 0.05$) in *E. regulus* and *A. peninsulae* between the control and the treatment areas. These results implied that population fluctuation was highly variable depending on season and habitat. Population abundance index of two species was greater in the control area than in the treatment area (Fig. 1 and 2). There were higher proportion of reproductively active animals in the control area than in the treatment area for *E. regulus* ($p = 0.03$) and *A. peninsulae* ($p = 0.04$) (Table 2).

There were significantly more residents of *E. regulus* in the control area than in the treatment area (Wilcoxon signed rank test, Z= -2.345, p=0.002), also difference in the number of transients between them (Z=1.428, p=0.03). There were more residents of *A. peninsulae* in the control

area than in the treatment area (Z = -1.724, p = 0.003), but no difference in the number of transients between the two areas (Z = -2.425, p = 0.142; Table 3).

The difference in the captured number of two small rodents between the two sites was caused by the differences in reproduction and residency.

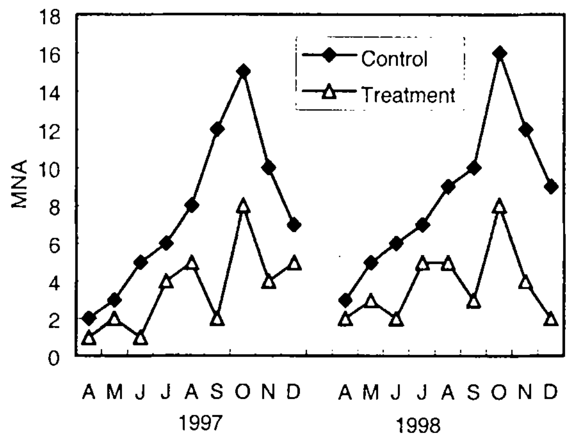

Fig. 1 Minimum number alive (MNA) of *Eothenomys regulus* in two study areas

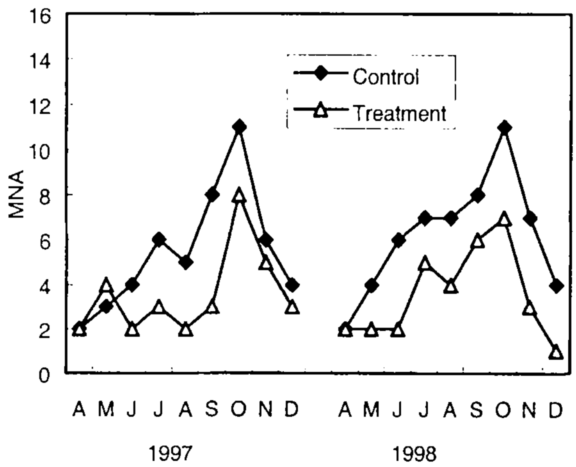

Fig. 2 Minimum number alive (MNA) of *Apodemus peninsulae* in two study areas

Table 2. Proportion of reproductively active *Eothenomys regulus* and *Apodemus peninsulae* in two study areas

Species	Sex	1997		1998		P
		Control area	Treatment area	Control area	Treatment area	
Eothenomys regulus	Female	0.29	0.20	0.33	0.22	0.03*
	Male	0.41	0.21	0.48	0.31	
Apodemus peninsulae	Female	0.50	0.32	0.30	0.23	0.04*
	Male	0.61	0.21	0.40	0.21	

* - denotes significant differences between the control and the treatment areas ($p<0.05$, Mann-Whitney U-test).

Table 3. Differences in residency portion of *Eothenomys regulus* and *Apodemus peninsulae* in two study areas.

Species	1997		1998	
	Control area	Treatment area	Control area	Treatment area
Eothenomys regulus	0.54 (37:31)[1]	0.31 (10 : 23)	0.66 (45 : 32)	0.40 (13 : 20)
Apodemus peninsulae	0.61 (30:19)	0.42 (13 : 18)	0.55 (31 : 25)	0.34 (11 : 22)

(residents : transients) [1]

Discussion

We could capture only two small rodent species, *Eothenomys regulus* and *Apodemus peninsulae* in study areas. We have observed several numbers of *Tamias sibiricus* but could not capture during the trapping season. There was no capture of *A. agrarius*, which is the most dominant small rodent species in South Korea. *A. agrarius* is not known to occur in humid area (Won, 1967). But there are many rainy and foggy days by the geological effect (Rhim 1997). The humidity may prevent the inhabitation of *A. agrarius* (Rhim and Lee 2001). Other small rodents could not be observed or captured in the study areas.

The control area in this study is a high quality habitat, which provided large amount of dead wood, i.e. volume of fallen trees and dead branches, and dense understory vegetation. The both of species were more abundant in the control area than in the treatment area. The control area may be more suitable habitat for the two species, because reproduction was more active and more resident mice were observed in the control area (Banach 1987; Mazurkiewicz, 1994).

Food resources and cover for escape from predator are important to most small rodent populations (Mazurkiewicz, 1994). *E. regulus* and *A. peninsulae* eats mainly herbs, seeds and berries (Won 1967; Yoon 1992). These food types occurred at the high coverage of understory vegetation in the control area.

E. regulus is a forest dweller, and the structure of the tree and bushes layer may be a factor determining its inhabitation and distribution (Rhim and Lee 1999). It has been reported that micro-distribution of *E. regulus* correlated closely with the amount of dead fallen trees, shrub cover and litter layer (Yoon 1992; Rhim and Lee 1999). And *A. peninsulae* preferred the area, which have amount of woody debris and pile of stones in forest floor (Rhim and Lee 2001).

There were greater population abundance and stability in the control area with large amount of dead wood and dense understory vegetation due to increasing structural diversity or habitat heterogeneity (Nakata and Konno, 1994; Lee, 1995). Theoretically, heterogeneous habitats appeared to support superior demographic performance, i.e. high density, reproductive rate and stability, than adjacent habitats that supported inferior demographic performance (Anderson 1980; Rhim and Lee 1998).

Several studies have stressed the importance of habitat heterogeneity in small mammal population dynamics (Hanson 1977; Myllymaki 1977; Anderson 1980; Stenseth 1980; Lee 1995). In this study, we measured the quantitative different amount of dead wood and coverage of understory vegetation. A high degree of habitat heterogeneity is characteristics of high density and increased reproductive rate in studies of *E. regulus* and *A. penisulae* (Rhim 1997). A high degree of habitat heterogeneity as measured by different amount woody debris and coverage of understory vegetation is correlated with high reproductive rate and residency in those two species. And a high number of captures on the control area these data could support the that sites with high amount of dead wood and coverage of understory vegetation were superior to sites with low amount of those.

The structure of forest floor appears to be important to the inhabitation of small rodents. Thus the forest structure may not directly influence the habitat of small rodents, but do it through affecting the conditions of forest floor. The presence of dead wood and understory vegetation after the forest cutting would be necessary for the maintenance of small rodents population at the forest cutting areas.

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